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IS 15407 (2003): Live Working - Guidelines for Dielectric Testing of Tools and Equipment [ETD 36: Tools and Equipment for Live Working]



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भारतीय मानक

चालू बिजली की लाईन पर कार्य करना—औजारों और
उपस्करणों के परावैद्युत परीक्षण के मार्गदर्शी सिद्धांत

Indian Standard

**LIVE WORKING—GUIDELINES FOR DIELECTRIC
TESTING OF TOOLS AND EQUIPMENT**

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

NATIONAL FOREWORD

This Indian Standards which is identical with IEC 61278 (1997) 'Live working — Guidelines for dielectric testing of tools and equipment' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendations of the Tools and Equipment for Live Working Sectional Committee (ET 36) and approval of the Electrotechnical Division Council.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. In the adopted standard, certain terminology and conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following.

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English text of the International Standard has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in IEC Publication.

CROSS REFERENCES

In this adopted standard, reference appear to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their places are listed below, along with their degree of equivalence for the editions indicated.

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 50 (151) (1978) International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices	IS 1885 (Part 74) : 1993 Electrotechnical vocabulary: Part 74 Electrical and magnetic devices	Identical
IEC 60-1 (1989) High-voltage test techniques — Part 1 : General definitions and test requirements	IS 2071 (Part 1) : 1993 High-voltage test techniques : Part 1 General definitions and test requirements (<i>second revision</i>)	do
IEC 93 (1980) Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials	IS 3396 : 1979 Methods of test for volume and surface resistivities of solid electrical insulating material (<i>first revision</i>)	Equivalent
IEC 112 (1979) Method for determining the comparative and the proof tracking indices solid insulating materials under moist conditions	IS 2824 : 1975 Method for determining the comparative tracking index of solid insulating materials under moist conditions (<i>first revision</i>)	do
IEC 243-1 (1988) Methods of test for electric strength of solid insulating materials — Part 1: Tests at power frequencies	IS 2584 : 1963 Methods of test for electric strength of solid insulating materials at power frequencies	do

(Continued on third cover)

Indian Standard

LIVE WORKING—GUIDELINES FOR DIELECTRIC TESTING OF TOOLS AND EQUIPMENT

1 Scope

This guide is intended to define the parameters to be used in the development of standards related to tools and equipment used in live working.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(151): 1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*

IEC 60-1: 1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 93: 1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 112: 1979, *Method for determining the comparative and the proof tracking indices solid insulating materials under moist conditions*

IEC 156: 1995, *Insulating liquids – Determination of the breakdown voltage at power frequency – Test method*

IEC 243-1: 1988, *Methods of test for electric strength of solid insulating materials – Part 1: Tests at power frequencies*

IEC 243-2: 1990, *Methods of test for electric strength of solid insulating materials – Part 2: Additional requirements for tests using direct voltage*

IEC 243-3: 1993, *Methods of test for electric strength of solid insulating materials – Part 3: Additional requirements for impulse tests*

IEC 587: 1984, *Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions*

3 Type of insulation system

The environment for tools and equipment used in live working can be categorized under four types with regard to the basic insulation medium:

- a) air: may be dry or humid; altitude affects the pressure;
- b) gases: corona aggression;
- c) liquids: water, oil;
- d) solids: organic or inorganic materials.

The fundamental systems to be evaluated are those primarily composed in whole or in part by type d) insulation or type a). The behaviour of inorganic materials is not greatly influenced by the duration, type or magnitude of electrical stress.

Organic materials are primarily composed of molecular structures that are susceptible to behaviour changes under electrical stress. The proper application of the stress factors such as temperature, voltage, time and humidity will ensure precise measurements which characterize the degree of safety of the insulating system.

4 Use of insulation system

The tools and equipment used in live working have various geometric shapes, such as rods, mats, gloves and sleeves. The energized parts or components that the tools are employed on also have different configurations. Thus, it is necessary to match the electrical behaviour pattern of the insulation with the electrical stress imposed by the energized components.

For example, hard cover-up used on energized conductors is essentially electrically stressed in two ways:

- punctures through the material distributed along the extended length;
- distribution of voltage stress on all or part of the surface from zero to a maximum value.

Thus, it is necessary that the dielectric testing method permits the discriminatory evaluation of the parameters of the insulation system.

5 Evaluation of the electrode shape

The shape of the different components of the tools and equipment used in live working during the performance of the work directly affects the laboratory and field testing of the shape of the electrodes (type vs. routine). The electrode configuration directly affects the voltage test characteristics. The electrode shape could be a rod type or a plane type, etc., depending on the form of the objects under evaluation.

The electrodes to be employed for a particular equipment should be precisely defined in shape and dimensions, including the rounding of edges and corners.

It should be recognized that the electrode shape for electrical evaluation shall simulate the system components on which it is used.

6 Equivalence of test voltage stresses

Tools and equipment (T & E), such as rods, blankets, line hoses and rigid covers can be subjected to various voltage stresses when used to protect workers during live line maintenance operations. On a.c. power systems, this equipment is usually exposed to steady state sinusoidal a.c. voltage, but may on occasion also experience surges of various waveshapes, produced by switching operations or possibly lightning strikes. On d.c. systems, the usual exposures are d.c. stresses.

The T & E shall withstand without failure all anticipated maximum electric stresses to which it will be subjected in service, in order to provide protection to the workers. Appropriate tests (type, routine) shall be developed to ascertain that the T & E can withstand these stresses.

Several important sets of data are needed for proper selection of the test criteria. It is necessary to have a good understanding of the expected stresses that are likely to be present during the use of the T & E. That is, if live work is not to be conducted when lightning is in the vicinity, then it may not be important or instructive to study the performance of T & E under lightning-related stresses. On the other hand, if distant lightning is likely to cause breaker tripping, then it may be necessary to know the resulting transient overvoltages that may propagate to the work location, and it may be necessary to confirm that the equipment can indeed withstand these expected switching surges. The magnitude and the waveshapes of the transient overvoltages are determined by the system characteristics, and the magnitude may in addition be controlled (reduced) by other means such as temporary protective gaps, or blocking reclosures.

Thorough knowledge of the electrical characteristics of T & E is also necessary. This information, that is, the breakdown voltage or the dielectric strength of the equipment, can only be obtained by actual laboratory tests. It should be noted that these tests could be destructive in nature. In the case of blankets, the determination of the breakdown voltage or dielectric strength requires application of sufficient voltage (stress) to cause the blanket to fail (puncture). Therefore, the destructive tests are not recommended for general use, and are made only on limited scale in the laboratory.

The breakdown strength obtained from such tests defines the maximum capabilities of the equipment for the test stress, that is, it determines the maximum stresses that the T & E will withstand without failure. Therefore, T & E withstand levels should be based on the maximum anticipated switching overvoltage, and related to the critical flashover value determined by experiments. References [2]*, [3] and [4] provide useful information on this subject.

As a guide, the maximum anticipated surge level for T & E rated up to 69 kV has been used as 3,0 p.u. for phase to earth. Also, based on ongoing research, the correlation factors for power frequency withstand, switching surge withstand, and d.c. withstand for T & E up to 69 kV can be summarized by the following:

a) *Switching surge/power frequency ratio*

Work is being continued to obtain a precise characteristic ratio for switching surge and power frequency. Based on available data, such a ratio for flexible insulated equipment appears to be 1,3. The ratio for rigid insulating covers, however, is different due to the effect of test electrodes, and it can range from 1,0 to 1,4. Until the testing is completed, no changes should be made to the power frequency withstand test voltages in existing or draft standards.

b) *DC/power frequency ratio*

Based on the test results, the d.c./a.c. peak ratio is greater than 1,0 and the presently used values may be questionable. Until the tests are finished and a characteristic ratio is determined, it is recommended that equivalent d.c. test voltages for a.c. rated T & E should not be given in the draft standards.

7 General principles of dielectric testing

The dielectric tests given in the standards of tools and equipment used are based on a combination of the following tests.

The two tests carried out on tools for live working are characterized as:

- a) **type test**; and
- b) **routine test**, which may be by sampling or acceptance.

* Figures in square brackets indicate a reference listed in annex A, Bibliography.

Type test (design) is performed on one or more devices made to a certain design to show that the design meets certain specifications [IEV 151-04-15]. Type testing involves a number of tests made under laboratory conditions to verify characteristics.

Routine test is one applied to each device during or after manufacture to ascertain whether it complies with certain criteria [IEV 151-04-16]. Routine testing is most often performed for production control, and on all the material(s) manufactured, or in the field.

Other tests involved are **sampling** and **acceptance** tests.

Sampling test is performed on a number of devices taken at random from a batch [IEV 151-04-17].

Acceptance test is a contractual test to prove to the customer that the device meets certain conditions of its specification [IEV 151-04-20].

The voltage tests should be associated with the operating voltages of the systems and the plants. These voltages could be the nominal system voltage, a multiple of this voltage, or the presence of transient. In general, power frequency voltage sources of 50 Hz and 60 Hz are chosen.

The correction of the determined values for altitude has not been indicated. The values presently given are accepted throughout for altitudes up to 1 000 m; for higher altitudes the following guidance is provided:

- the electric strength of an air gap is reduced at high altitude, principally due to the reduced air pressure
- an increase of 3 % in the clearance for every 300 m above 1 000 m is recommended.

8 Accuracy for the classification of materials or equipment

For nominal voltage(s), the effective voltage deviations are generally estimated to 10 %. The voltage spread should be taken into account to define the precision of the expected measurements.

The test voltage is expressed in terms of:

- a) a prorated value;
- b) a multiple of the nominal system voltage; or
- c) rated voltage of the material.

When the overvoltage reaches the test per unit margin value of 5, it is useless to require a high accuracy of the measurements. When this test margin is near 1,0, a higher accuracy is essential. In this case, the general requirements for measuring a.c. voltages are (see reference [2]):

- measure r.m.s. or crest value of voltage with accuracy of not less than 3 %;
- measure the amplitude of harmonics with an error not exceeding the highest of the following two values: 10 % of the amplitude of harmonics, or 1 % of the primary wave.

For current measurement through the test object, a number of separate components of the current may be recognized, which differ from each other by several orders of magnitude for the same test object and test voltage. Currents encountered in the evaluation of live working tools and equipment may differ and can be characterized as:

- a) capacitive;
- b) continuous leakage;
- c) partial discharge.

The relative magnitude and the importance of each component depend on the type and the condition of the test object, the purpose for which the test is being made, and the duration of the test. Accordingly, the measurements are specified for the kind of tool and equipment.

9 Scope of references

There are numerous documents that cover dielectric testing. Many of the publications have purposes or scopes related to some of the points enumerated above.

Listed are some of these publications, together with a description of the contents of the publication and short comments as how they view specification of duration, voltage rate or rise, application technique and use environment. They are:

IEC publications:

IEC 60-1: 1989, *High voltage test techniques – Part 1: General definitions and test requirements*

This standard is applicable for dielectric tests with direct voltage; dielectric tests with alternating voltage; dielectric tests with impulse voltage and impulse current; and tests with combinations of these.

IEC 93: 1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

This standard gives test procedures and calculations for the determination of volume and surface resistivity. It establishes recommendations for: values of voltage and time application; nature and geometry of electrodes; temperature and humidity of atmosphere and test specimens; conditioning of test specimens.

IEC 112: 1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

This standard describes a method of test intended to indicate the relative resistance of solid electrical insulating materials to tracking for voltages up to 600 V when exposed under electric stress to water with the addition of contaminants on the surface. It has the value of a basic safety publication in accordance with *IEC Guide 104*.

IEC 156: 1995, *Insulating liquids – Determination of the breakdown voltage at power frequency – Test method*

This standard describes an empirical test procedure intended to indicate the presence of contaminants such as water and solid suspended matter, and the advisability of carrying out drying and filtration treatment. Standardized testing procedures and equipment are essential for the unambiguous interpretation of test results.

IEC 243-1: 1988, *Methods of test for electric strength of solid insulating materials – Part 1: Tests at power frequencies*

This standard gives methods of test for the determination of the short-time electric strength of solid insulating materials at power frequencies (48 Hz to 62 Hz).

IEC 243-2: 1990, *Methods of test for electric strength of solid insulating materials – Part 2: Additional requirements for tests using direct voltage*

This publication gives requirements additional to those in IEC 243-1 for the determination of the electric strength of solid insulating materials under direct voltage stress.

IEC 243-3: 1993, *Methods of test for electric strength of solid insulating materials – Part 3: Additional requirements for impulse tests*

This standard gives requirements, additional to those in IEC 243-1, for the determination of the electric strength of solid insulating materials under impulse voltage stress.

IEC 587: 1984, *Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions*

This standard describes two test methods (constant tracking voltage and stepwise tracking voltage) for the evaluation of electrical insulating materials for use under severe ambient conditions and power frequencies (48 Hz to 62 Hz) by measurement of the resistance to tracking and erosion. The publication has the status of a basic safety publication in accordance with *IEC Guide 104*.

Other publications:

ASTM D 149-88: *Standard test method for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies*

The method covers a procedure for determination of solid insulating materials at various temperatures, and in any suitable gaseous or liquid surrounding medium. The method is most commonly used to determine the dielectric breakdown voltage through the thickness of a test specimen (puncture). In Method A, **Short-time test**, the voltage is increased from zero at a rate determined in advance until breakdown occurs. This **Short-time test** is used unless otherwise specified. In Method B, **Step-by-step method**, the voltage is applied to the test electrodes at the preferred starting voltage and in steps and duration predetermined until breakdown occurs. In Method C, **Slow rate-of-rise test**, the voltage is applied to the test electrodes, from the starting voltage and increased at the rate predetermined, until breakdown occurs.

ASTM D 877-87: *Standard test method for dielectric breakdown voltage of insulating liquids using disk electrodes*

This test method covers a reference and a routine procedure for determining the dielectric breakdown voltage of insulating liquids. The dielectric breakdown voltage of an insulating liquid is of importance as a measure ability of the liquid to withstand dielectric stress without failure. It serves to indicate the presence of contaminating agents giving low dielectric breakdown values.

The procedure consists in finding the dielectric breakdown voltage level of a liquid.

ASTM D 1816-84a: *Standard test method for dielectric breakdown voltage of insulating oils of petroleum origin using VDE electrodes*

This test method covers the determination of the dielectric breakdown voltage of insulating oils of petroleum origin. The procedure uses the rate of rise of voltage, which consists in applying the voltage and increasing from zero at the rate of approximately 500 V/s until breakdown occurs.

IEEE Std 4-1995: IEEE Standard techniques for high-voltage testing

This standard is applied to dielectric tests with direct voltage; dielectric tests with alternating voltage; dielectric tests with impulse voltage and impulse current; and tests with combinations of these.

10 Application of guidelines for test procedures

A number of publications have been prepared that discuss all aspects of HV testing. The most important IEC publications are:

- IEC 60-1;
- IEC 243-1;
- IEC 243-2;
- IEC 243-3.

A recent and complete series has also been issued by ASTM with the title of "Engineering dielectrics". The subject matter of this series encompasses various practical and theoretical facets of dielectric materials suitable for electrical purposes. They are:

ASTM STP 669: *Corona measurement and interpretation*

ASTM STP 783: *Electrical properties of solid insulating materials, molecular structure and electrical behaviour*

ASTM STP 926: *Electrical properties of solid insulating materials: Measurement techniques*

It is well known that the dielectric strength of an insulating material will decrease as temperature increases. Small variations in the ambient temperature are of little consequence. Should a given material be stressed by temperatures very different from room temperature, then the breakdown strength should be determined as a function of temperature. The variation in magnitude will depend upon the nature of the materials.

The breakdown voltage in air depends on the atmospheric conditions: temperature (t), pressure (p), and absolute humidity (h). The measured breakdown voltage U obtained at a particular set of conditions (t, p, h) can be related back to the standard conditions $t_0 = 273$ °C, $p_0 = 101,3$ kPa, and $h_0 = 11$ g/m³ by two atmospheric correction factors, see IEC 60-1:

- the air density correction factor k_1 ;
- the humidity correction factor k_2 ;

The corrected breakdown voltage U_0 at standard atmospheric conditions is calculated as:

$$U_0 = U / K_t$$

where $K_t = k_1 \times k_2$

The air density correction factor k_1 depends on the relative air density δ :

$$k_1 = \delta^m$$

where

$$\delta = \frac{p(273 + t_0)}{p_0(273 + t)}$$

m is an exponent obtained from figure 4 in IEC 60-1.

The humidity correction factor k_2 is expressed as:

$$k_2 = k^w$$

where

w is an exponent obtained from figure 4 in IEC 60-1; and

k is a parameter that depends on the type of test voltage, length of the gap, and gap configuration. Its value is determined using the procedure described in IEC 60-1.

The combination of temperature and air pressure that gives the lowest gap breakdown voltage is high temperature and low pressure. These atmospheric conditions are very unlikely to occur simultaneously. Low air pressure is generally associated with high humidity. Therefore, hot and dry working conditions are normally associated with reduced dielectric strength.

In carrying out routine breakdown tests on solid or liquid electrical insulating materials, it should be borne in mind that commercially available materials tend to be non-homogeneous, and may contain various dielectric defects. Dielectric breakdown will normally occur at a defect site that may be located far from the area of maximum dielectric stress, and be remote as well from the area situated directly beneath or adjacent to the test electrode(s). Such weak sites within the dielectric bulk will thus determine the value of the dielectric strength. Thickness must be fully appreciated, since the dielectric strength (in kV/m) of solid insulating material(s) generally decreases with increasing specimen thickness. For homogeneous materials, this decrease varies approximately as the reciprocal of the square root of the thickness, though, in the case of solidifying liquids, the exact influence of thickness is less well defined. It is thus apparent that the dielectric strength value given without stating the specimen thickness is rather meaningless. In the case of tools and equipment used for live working, the required minimum dielectric strength should be specified regardless of its thickness.

The obtained a.c. breakdown strength is also a function of the rate of voltage application. In general, the a.c. breakdown voltage value exhibits an increase with increasing rate of voltage application, most often because both the time-dependent thermal breakdown mechanisms and the corona degradation processes have less time to give rise to instabilities. The impulse breakdown strength generally increases with the rise time of the impulse wave.

In a.c. breakdown tests, the voltage is applied across the specimen, either gradually or in a step-wise manner until breakdown of the specimen occurs. For gradual voltage application, a distinction is further made as to whether the voltage is applied at a relatively rapid rate (that is, a **short-time test**) or is raised more slowly (that is, a **slow rate-of-rise test**). For the **short-time test**, a rate of 500 V/s is normally used, which further stipulates that a short-time breakdown must take place between 10 s to 20 s following the application of voltage. This requirement, in part, ensures that the specimen is not unduly aged due to a voltage overstress before breakdown.

Accordingly, with some materials, the highest specified value of 500 V/s may have to be used.

For the **slow rate-of-rise test**, the maximum acceptable rate of voltage rise is 100 V/s. This method of application differs from the **short-time test** in another way. Instead of commencing the test at zero applied voltage, a voltage, V_s , is suddenly applied across the specimen before the specified gradual increase in voltage (see figure 1a). The value of V_s is set approximately to 50 % of the breakdown voltage V_{bd} determined in a preliminary **short-time test**.

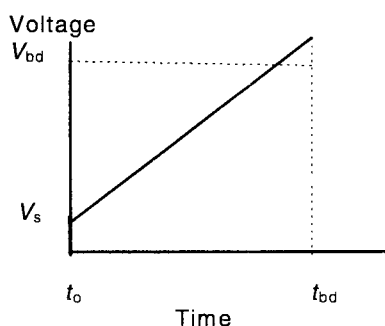


Figure 1a – Slow rate-of-rise test

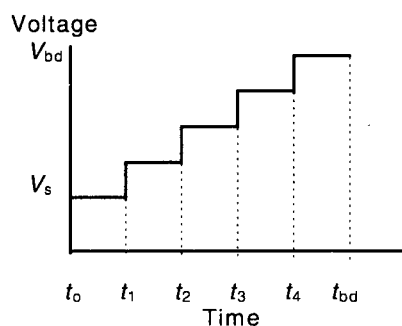


Figure 1b – Step-by-step test

Figure 1 – Voltage profile

In the **step-by-step test** (see figure 1b), the initial voltage value, or step, is usually set also at V_s . When using the **slow rate-of rise test**, it is customary to select a rate of rise that approximates the average slope, or rate, of the **step-by-step** characteristic.

In the case where air is the basic insulation, it is recommended to specify the test procedure. An example of an accepted test procedure description is given below (see 14.1 and 17.1 of IEC 60-1):

In the **rated withstand voltage test**, "The voltage shall be applied to the test object starting at a value sufficiently low to prevent any effect of overvoltages because of switching transients (...), but not so slowly as to cause unnecessary prolongation of the stressing of the test object near to the test voltage U . These requirements are in general met if the rate of rise is about 2 % of U (the puncture voltage) per second, when the applied voltage is above 75 % of U ."

In many cases where the voltage remains lower or equal to 100 kV, a slope of 1 kV/s is then considered compatible with the preceding recommendation.

Nevertheless, it is easier to maintain the slope of constant voltage in the laboratory, rather than a time lapse to reach the test voltage.

For voltages higher than 100 kV, the duration of the voltage rise should not exceed 1 min, the slope being adjusted according to the laboratory facilities.

For corona discharge test conducted to determine visual corona onset, it is recommended that a test using a partial discharge detector be made prior to the actual a.c. voltage test. In the actual test, an a.c. voltage is raised sufficiently to indicate detector response to partial discharge; however, the applied voltage in the partial discharge test must never exceed the alternating current test voltage. The voltage is subsequently lowered normally at a rate more than 2 000 V/s to determine the partial discharge extinction level

Although exactly defined test conditions might not in all cases be necessary to ensure safe working with a tool or equipment, they cannot be dispensed with, since otherwise test results are not reproducible, and a device which successfully passed the tests in the laboratory may fail in another and vice-versa.

A review of the cited references and other standards, together with the experience developed through the use of standards already promulgated, wherein a rate of rise and the voltage level were specified, indicates the following appropriate general guideline(s) for documents relating to tools and equipment:

Dielectric strength of solid and gaseous (air) insulation:

- 1 000 V/s for voltages up to 100 kV; and
- for voltages above 100 kV, a voltage time rise of less than 1 min.

For special situations not covered in this report, a further review of test procedures is appropriate.

Annex A
(informative)

Bibliography

- [1] IEC 60-2: 1994, *High-voltage test techniques – Part 2: Measuring systems*
 - [2] IEC 71-1: 1993, *Insulation co-ordination – Part 1: Definitions, principles and rules*
 - [3] IEC 71-2: 1976, *Insulation co-ordination – Part 2: Application guide*
 - [4] IEC 71-3: 1982, *Insulation co-ordination – Part 3: Phase-to-phase co-ordination – Principles, rules and application guide*
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(Continued from second cover)

<i>International Standard</i>	<i>Corresponding Indian Standard</i>	<i>Degree of Equivalence</i>
IEC 587 (1984) Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions	IS 9947 : 1981 Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions	Equivalent

The Technical Committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards referred to in this adopted standard and has decided that it is acceptable for use in conjunction with this standard.

<i>International Standard</i>	<i>Title</i>
IEC 156 (1995)	Insulating liquids — Determination of the breakdown voltage at power frequency — Test method
IEC 243-2 (1990)	Methods of test for electric strength of solid insulating materials — Part 2: Additional requirements for tests using direct voltage
IEC 243-3 (1993)	Methods of test for electric strength of solid insulating materials — Part 3: Additional requirements for impulse tests

For the purpose of deciding whether a particular requirement of this standard is complied with final value observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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